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Dina Lake #1 Pygmy Whitefish (*Prosopium coulteri*) Study: Stomach Contents Analysis #2, 2001

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Abstract

Little is known about the biology and feeding habits of pygmy whitefish (*Prosopium coulteri*) in British Columbia. In this paper, ecological requirements of foraged items found in the fish's stomachs were used to infer summer feeding habits of pygmy whitefish in Dina Lake #1. Pygmy whitefish were gill netted from the lake at four intervals separated by approximately one month during the spring, summer, and fall of 2000 and 2001. Relative abundance estimates of all taxonomic groups found in each stomach were determined in the laboratory then compared between years. A literature review for each foraged taxonomic group was used to appoint them either into a benthic or limnetic ecological category. During both years, pygmy whitefish fed predominantly on crustaceans and insect larvae that live in the water column (limnetic) but benthic invertebrates (predominantly chironomidae larvae) were also found in the stomachs. Similar taxonomic groups were found in the stomachs during both years, although the abundance of benthic organisms (mostly chironomidae larvae) was slightly greater in the 2001 samples. Cyclopoid copepods (limnetic) were the most important food item during the spring and early summer, and then cladocera and calanoid copepods (both also limnetic) dominated the stomach contents later during mid-summer and fall. Chironomid larvae were also more abundant in the stomachs during the spring but were also found in stomachs collected during all sample periods. The results from this study strongly suggest that pygmy whitefish in Dina Lake #1 forage predominantly from the water column during the summer but they also forage from the benthos. The results also suggest that separate foraging strategies are required to successfully capture either benthic or limnetic organisms. Feeding from the benthos might be more important during the less productive winter months in Dina Lake #1.

Introduction

Very little is known about the biology and habitat use of pygmy whitefish (*Prosopium coulteri*). In lakes, this little fish is most often found at depths below the productive euphotic zone and it is often assumed that they forage predominantly on benthic organisms (Lindsey and McPhail 1970). In fact, benthic insect larvae and molluscs are listed food items for this whitefish and chironomid larvae are a major food source for Alaskan populations (Scott and Crossman 1973; Carl et al.1976). Nonetheless, planktonic crustaceans have also been found in pygmy whitefish stomachs collected from Lake Superior (Scott and Crossman 1973). Such a wide range of food items that live in distinct habitats (e.g. benthic and limnetic) suggests that *P. coulteri* is quite adaptable in feeding habits.

Pygmy whitefish were studied for two years by the Peace/Williston Fish and Wildlife Compensation Program (PWFWCP) as part of a research project that was aimed at determining some of the basic life history strategies for this species. The intent of this study was to fill in some of the information gaps relating to age and growth, especially young-of-the-year (y-o-y), proper field identification, spawning/reproduction, food items consumed, and habitat use throughout the summer months. The data collected pertaining to this fish study (e.g. morphology, sex, age) and sample sites are presented in McPhail and Zemlak 2001 and Zemlak and McPhail 2004. This paper summarizes the methods and results obtained in the laboratory from stomach contents analysis of fish samples collected from Dina Lake #1 during the summer of 2000 and 2001.

Methods

Pygmy whitefish were captured from Dina Lake #1 during spring, summer, and fall of 2000 and 2001 and stomach samples were taken from several of these fish (Table 1). The same procedure was used to process the stomach contents from samples collected during both years (Stamford 2001). Relative abundance estimates of taxonomic groups found inside each stomach sample, together with known ecological requirements and habitat use for these taxa, were used to infer important summer foraging areas used by pygmy whitefish. Taxonomy of the items collected from the stomach contents were determined using keys from Pennak (1978), Merritt and Cummins (1996), Sandercock and Scudder (1996) and Green et al. (1997).

The aim of the stomach contents analysis was to determine the taxonomy of foraged organisms and estimate their abundance in each pygmy whitefish. Prey items were identified and their relative abundance in each stomach sample was estimated by eye through a dissecting microscope. Abundance of each taxon was assigned to one of the following four proportions of the total bolus volume: 0% - 25%, 25% - 50%, 50% - 75%, 75% - 100%. This procedure was chosen because it enabled direct rapid assessment of biomass of the taxa without spending large amounts of time required for enumeration of individual organisms and biomass measurement. Although such wide biomass measurement categories have low precision, they provide consistent and accurate estimates of relative abundance within and among samples and sampling periods. They are, consequently, useful for determining the dominant prey and inferring, from the ecological requirements of these prey specimens, the general foraging habitats utilized by pygmy whitefish in Dina Lake #1. All of the specimens extracted from the stomachs

during 2000 and 2001 remain in their respective labeled vials and are available for further analysis if required.

Table 1: Pygmy whitefish sample collection periods during 2001 and 2000 showing fish sample sizes, stomach sample sizes, and sample identification numbers.

Sampling Period	Number of Pygmy whitefish Collected	Sample Set Number	Stomach Sample Size
May, 2001	4	1 to 4	3
June, 2001	46	5 to 51	32
July, 2001	99	52 to 150	31
August, 2001	106	151 to 256	38
October, 2001	103	257 to 359	29
November, 2001	9	360 to 368	2
Total	**367**		**135**
June, 2000	150	1 to 150	45
July, 2000	58	151 to 208	49
September, 2000	54	209 to 262	25
October, 2000	60	263 to 322	30
Total	**322**		**149**

Data Analysis (carried out for both 2000 and 2001 sample series)

These data provide relative abundance (biomass) estimates of taxonomic groups in each stomach sample measured on an ordinal scale. Non-parametric statistics were chosen for analysis because these data (as for other ordinal scale data , Zar 1984) are not normally distributed. For example, the 'population' of abundance measures has a positive skew resulting from high relative frequency of the lower abundance measures. There is a greater probability of randomly sampling low biomass measures (i.e. 0 - 25% and 25 - 50%) over high biomass measures (i.e. 50-75% and 75-100%) from the population of biomass measures because low measures are more common (Figure 1 A). The nature of the measurements makes it physically impossible for more than one measure of 75 – 100% to exist for a single stomach while there can be numerous 0 – 25% and 25 – 50% measurement categories for a single stomach.

Descriptive statistics were facilitated by assigning the abundance measures a number (or rank) between one (for the 0 - 25% proportion) and four (for the 75 -100% proportion), which were used to generate frequency distributions, calculate medians and overall relative abundance charts. These ranks are not the same as those used to calculate the non-parametric statistics. Statistical tests for differences between abundance measures employed the Mann-Whitney Test for Ordinal Data, which is a non-parametric version of the t-test (Zar 1984). Although this test is conservative (about 95% as powerful as parametric statistics) it is one of the most powerful types of non-parametric tests. Corrections for multiple comparisons followed the Bonferroni adjustment (Rice 1989).

Correlation analysis was used to examine the relationships between abundance of taxa within stomachs and frequency of occurrence among stomach samples as well as between benthic and limnetic abundance measures within the same stomachs (Figure 1 B & C). For both analyses, abundance measures within each group (i.e. ecotype abundance within each stomach, and overall abundance for each taxon across all stomachs) were the average values calculated from the assigned ranks described above (i.e. 1- 4). Frequency of occurrence was calculated using the following equation:

$$\text{Frequency of Taxon X in Stomach Samples} = \frac{\text{Number of Stomachs in which Taxon X was found}}{\text{Total number of stomach samples examined}}$$

This equation translates into the proportion of the total number of stomach samples a given taxon was found within a year. The Spearman Rank Correlation procedure (Zar 1984) was then employed to determine the strengths of each relationship.

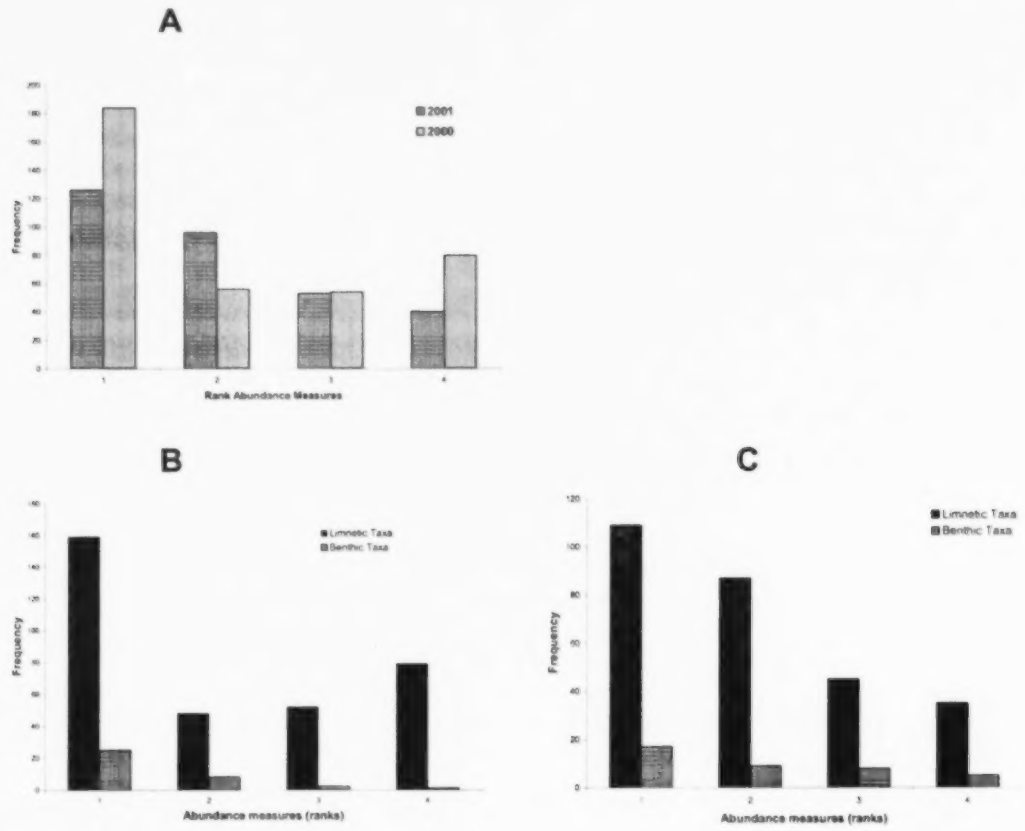


Figure 1: Frequency distribution of stomach contents abundance measures among (A) all samples collected in 2000 and 2001, and (B) for benthic and limnetic grouped separately during 2000, and (C) for benthic and limnetic grouped separately during 2001. Numbers along the X-axis pertain to the four following abundance measures: 1 = 0% - 25%; 2 = 25% - 50%; 3 = 50% - 75%; 4 = 75% - 100%.

Assigning taxa into ecotypes.

Specimens found in the stomach contents were designated either into benthic or limnetic ecotypes by consulting the literature. Benthic ecotypes included taxa or life history forms that live in or on the lake bottom, either in littoral areas or at depths below the euphotic zone. Hydracarina, *Hyalella azteca*, Ephemeroptera naiads and Trichoptera larvae were defined as benthic ecotypes that live in littoral areas where they crawl along the bottom, on aquatic vegetation and other substrata while searching for food (Pennak 1989; Merritt and Cummins 1996).

Similarly, Chironomidae larvae were defined as benthic ecotypes that inhabit the benthos among littoral algae and other aquatic vegetation but there are also species within this family that live at various depths below the euphotic zone (Merritt and Cummins 1996). Further taxonomy of the chironomidae might distinguish between littoral and hypolimnetic benthic ecotypes, but viewing their distinguishing characteristics requires extensive preparation and examination under high magnification (Merritt and Cummins 1996).

Limnetic ecotypes included taxa or life history forms that are free swimming and would be consumed by fish foraging in the water column. Clearly defined limnetic ecotypes included the Copepoda (Cyclopoida and Calanoida), four Cladocera genera (*Daphnia, Bosmina, Leptodora, Alona*) and Chaoboridae larvae. Although rare benthic oriented calanoid and cyclopoid species exist, the small size and slight morphology of the specimens found in these stomach samples reflect adaptations for swimming, which strongly suggests that they carry out their life history suspended in the water column (Balcer et al. 1984; Pennak 1989). Similarly, there are benthic oriented cladocera species, but the genera found most abundantly in the pygmy whitefish stomachs included species that are common members of the limnetic zooplankton community (e.g. *Daphnia* likely included *D. galeata*, *D. longiremis* and *Diaphanosoma birgei*; *Bosmina* likely included *Eubosmina longispina*; Danusia Dolecki pers. comm.).

Similarly, other studies have found both Chaoborus larvae and *Leptodora* in benthos samples of some lakes and some *Alona* species occur at the sediment-water interface (Balcer et. al. 1984; Merritt and Cummins 1996). These groups are also commonly sampled from the water column, however, and they were designated as limnetic organisms in this study because they swim to move around and likely do not burrow or crawl along the lake bottom. Correct designation of these limnetic ecotypes, however, should be confirmed by comparing their taxonomy with samples collected from the water column of Dina Lake #1.

Chironomidae pupae were also grouped into the limnetic ecotype because they are highly susceptible to predation by fish (e.g. rainbow trout: Johnston et al. 1999) while they migrate from the benthos to emerge as adults at the surface. Pygmy whitefish likely have alternative feeding strategies from trout, however, and there is evidence that chironomid pupae minimize their time in the water column by remaining hidden in the benthos or among other bottom substrata until just before they emerge as adults (Merritt and Cummins 1996). Consequently, pygmy whitefish could target this prey using a benthic foraging strategy or a limnetic strategy, but this life history stage was considered more susceptible as prey in the water column.

Results from Stomach Contents Analysis

Among the 135 samples collected during 2001, a total of 20 stomachs were empty and they were distributed between August samples (11) and October samples (9) (Appendix 1). Among the 149 samples collected in 2000 a total of 12 stomachs were empty (two during June and nine during September; Appendix 2).

The positive skew to the frequency distribution of abundance measures was less severe for the 2001 samples (Figure 1 A) because several abundant taxa were found together in individual stomach samples. Consequently, the frequency of the second lowest abundance category (i.e. rank 2 marking the 25 – 50% category) was greater in the 2001 samples. The frequency of the highest (75 – 100%) and lowest (0 – 25%) abundance measures, however, were greater in the 2000 samples (Figure 1). These effects were mostly due to abundance measures of limnetic taxa (Figure 1 B and C). The overall abundance of limnetic taxa, however, was not significantly different between years ($Z=0.5433$, $p>0.50$, 2 tail; Table 2).

Table 2: Median abundance measures and number of stomachs containing a taxonomic group (Ni) in Dina Lake #1 pygmy whitefish samples collected during 2000 and 2001. Numbers in the median abundance column pertain to the following abundance measures: 1 = 0% - 25%; 2 = 25% - 50%; 3 = 50% - 75%; 4 = 75% - 100% (see methods for details). The proportion of stomachs containing the taxonomic groups was also shown because this measure was an important factor in determining statistically significant comparisons between years. Taxa that showed a statistically significant difference in abundance between years are highlighted with bold font and marked with asterisks. Bonferroni adjusted significance level was $p<0.002$.

	Collected during 2000				Collected during 2001			
	Ni	Proportion of stomachs (Ni / total # stomachs)	Median Abundance	Range of Ranks	Ni	Proportion of stomachs (Ni / total # stomachs)	Median Abundance	Range of Ranks
Benthic Taxa								
Ephemeroptera naiad	1	0.01	1	0 - 1	1	0.01	1	0 - 1
Trichoptera larvae	4	0.03	1	0 - 1	0	0.00	0	0
Chironomidae larvae	**25**	**0.17***	**1***	**0 - 3**	**36**	**0.27***	**2***	**0 - 4**
Hyalella azteca	2	0.01	3	0 - 4	0	0.00	0	0
Hydracarina	3	0.02	1	0 - 3	2	0.01	3	0 - 4
All Benthic Taxa	**35**	**0.24***	**1***	**0 - 4**	**39**	**0.29***	**2***	**0 - 4**
Limnetic Taxa								
Chironomidae pupae	17	0.11	3	0 - 4	25	0.19	2	0 - 4
Chaoboridae larvae	9	0.06	1	0 - 3	11	0.08	2	0 - 2
S.O. Cyclopoida	68	0.46	2	0 - 4	61	0.45	2	0 - 4
S.O. Calanoida	67	0.45	2	0 - 4	47	0.35	1	0 - 4
Daphnia	**95**	**0.64***	**3***	**0 - 4**	**57**	**0.42***	**2***	**0 - 4**
Bosmina	**51**	**0.34***	**1***	**0 - 3**	**63**	**0.47***	**2***	**0 - 4**
Leptodora	28	0.19	1	0 - 3	8	0.06	2	0 - 2
Alona	3	0.02	1	0 - 1	5	0.04	1	0 - 1
All Limnetic Taxa	338	2.27	2	0 - 4	277	2.05	2	0 - 4

Note: stomach sample size in 2000 = 149 while the sample size in 2001 = 135

Eleven taxonomic groups were distinguished in the 2001 stomach samples and thirteen groups were identified in the 2000 samples (Trichoptera larvae and *Hyalella azteca*

were not found in 2001; Table 2). Copepods (both Cyclopoida and Calanoida) and cladocera (*Daphnia* and *Bosmina*) were clearly foraged most abundantly by the pygmy whitefish during both years although their overall relative abundance measures were different between years (*Bosmina* abundance showed a particularly large increase in 2001; Figure 2). Chironomidae larvae and Chironomidae pupae were the next most abundant foraged items in the stomach samples overall during both 2000 and 2001, but both made up a larger proportion of the overall bolus volume in 2001 (Figure 2).

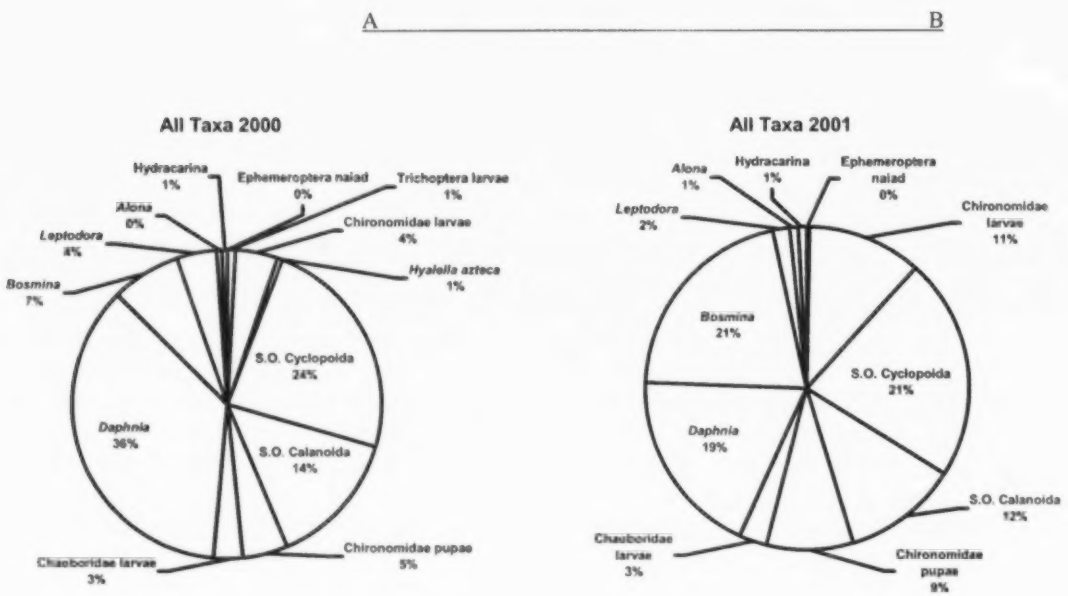
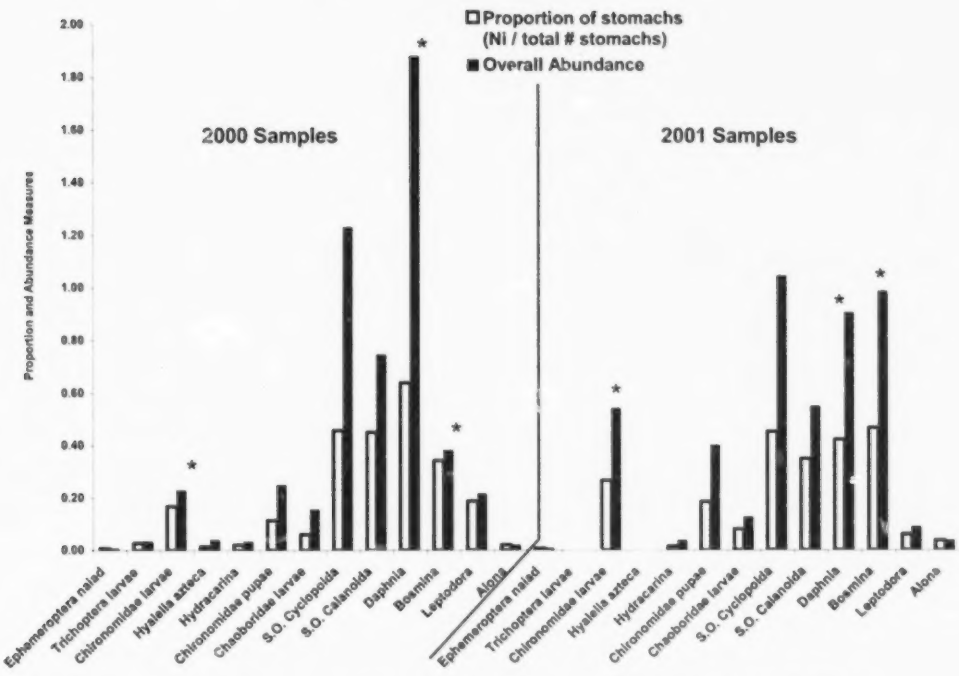


Figure 2: Proportional abundance of invertebrate taxa found in Pygmy whitefish stomach samples collected during 2000 (A) and 2001 (B). Note that these charts show the overall relative abundance of taxa calculated across all stomach samples collected within years.

Overall abundance measures for all taxa were strongly correlated with the proportion of stomachs in which the taxa were found (r_s= 0.935 and 0.988 for 2000 and 2001 samples, respectively, see Figure 3). These data suggest that the same taxonomic groups that were foraged in large quantities by individual pygmy whitefish were also popular food items among all pygmy whitefish. The exception to this was *Hyalella azteca* and Hydracarina, which were only found in two or three stomach samples but also in high abundance in at least one of those stomachs (Table 2). Among the limnetic taxa, *Daphnia* were statistically significantly more abundant in the pygmy whitefish stomachs collected in 2000 compared to 2001 (Z= 4.338, $p<0.001$, 2 tailed; Table 2). The opposite was true for *Bosmina*, however, which were found in greater abundance in the 2001 stomachs (Z= 6.102, $p<0.001$, 2 tailed; Table 2).



* = Abundance measures between years were statistically significant ($p<0.002$, see Table 2).

Figure 3: Histogram showing overall abundance measures and the proportion of stomach samples that each taxonomic group was found in the 2000 and 2001 samples. Both values were highly correlated (see text). Note that the proportions of stomach samples values did not differ much between years for these taxa.

The overall mean abundance of benthic taxa was greater in 2001 compared to 2000 (Figure 3; $Z=2.598$, $0.005<p<0.01$, 2 tailed), and this difference was largely due to greater abundance of chironomidae larvae in the 2001 samples ($Z= 2.529$, $0.01<p<0.02$, 2 tailed; Table 2). Absence of Trichoptera larvae and *Hyalella azteca* in the 2001 samples was not as important statistically as greater abundance of chironomidae larvae in the 2001 samples likely because the former taxa were rare within and among the stomach samples (Table 2).

Abundance measures of benthic and limnetic ecotypes in the stomach samples were negatively correlated for both years (Figure 4). Although, there was a stronger relationship among 2001 samples ($r_s = -0.5945$, $p<0.001$) compared to the 2000 samples ($r_s= -0.1796$, $0.02<p<0.05$). The reason the correlation explained a larger proportion of the 2001 data was largely due to high abundance of chironomidae larvae in stomach samples that did not contain high abundance of limnetic taxa (Appendices 1 and 2).

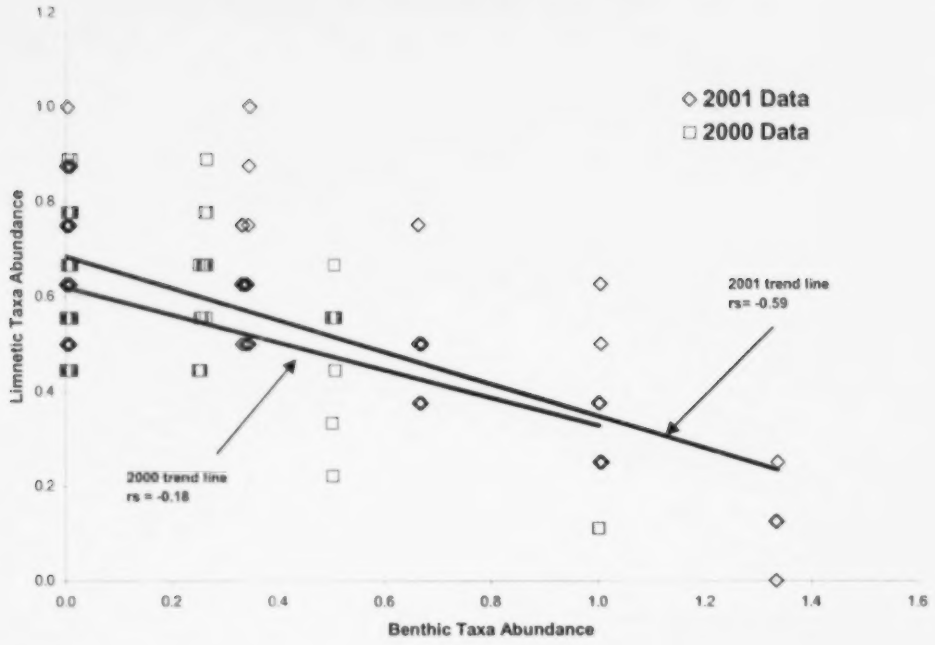


Figure 4: Correlation between abundance measures of benthic and limnetic ecotypes found in individual pygmy whitefish stomach samples collected during 2001 and 2000. Benthic data were 'jittered' slightly to display the coordinates that contain several data points. Abundance measures along the x-axis were calculated using transformed abundance measures (see Methods). Trend lines illustrated for clarity.

Pairwise comparisons between taxonomic groups within years found more statistically significant differences among taxa in the 2000 samples than in the 2001 samples (Figure 5). Statistically significant pairwise comparisons among the 2001 taxa always included calanoid copepod abundance and all other comparisons failed to show significance. These results were largely due to absence of the 50 – 75% (rank 3) abundance class in the calanoid copepods. The Mann-Whitney U test was more sensitive to differences in the proportions of each abundance class within groups and less sensitive to overall abundance measures that could be a function of sample size. Consequently, frequent non-significant pairwise comparisons between taxa in the 2001 samples (Figure 4) indicate that the distribution of abundance measures within taxonomic groups was similar (Appendix 3).

Similarly, non- significant pairwise comparisons in the 2000 samples were found between taxa that contained many low abundance measures (e.g. both Chironomidae larvae and *Bosmina* were never the most abundant (75 – 100% class) organisms in 2000) or contained many from each abundance class (e.g. Chironomidae pupae and Calanoida). Other non-significant results in the 2000 samples, however, were between taxa that were frequently found in high abundance (e.g. *Daphnia* and Cyclopoida; Figure 4). Chironomidae pupae were also found in high abundance frequently enough that their abundance was not significantly different from the two most abundant taxa (i.e. *Daphnia* and Cyclopoida). Nonetheless, this latter result might be an artifact of very

large differences in sample size (i.e. chironomidae pupae were found in fewer stomachs than both *Daphnia* and Calanoida; Table 2), which reduces the power of this test (Zar 1984).

2001 Samples

	Chironomidae larvae	Chironomidae pupae	Cyclopoida	Calanoida	*Daphnia*	*Bosmina*
Chironomidae pupae	0.47					
Cyclopoida	1.60	0.59				
Calanoida	2.32	2.24	**4.84***			
Daphnia	0.66	0.05	1.28	**3.90***		
Bosmina	0.58	0.19	1.49	**3.96***	1.00	

2000 Samples

	Chironomidae larvae	Chironomidae pupae	Cyclopoida	Calanoida	*Daphnia*	*Bosmina*
Chironomidae pupae	1.65					
Cyclopoida	**6.10***	1.51				
Calanoida	1.93	1.69	**6.19***			
Daphnia	**7.96***	**3.12***	1.22	**10.85***		
Bosmina	1.72	**13.89***	**7.96***	**4.44***	**13.08***	

Bonferroni adjusted Significance Value

* = $p<0.002$ $Z_{0.002(2),infinity} = 3.09$

Figure 5: Results from Mann-Whitney U tests showing Z-values from pairwise comparisons of abuindance measures among the six most abundant taxonomic groups found in the 2001 and 2000 samples. Bonferroni adjusted statistical significance are highlighted in bold font and marked with an asterisk.

Discussion

Cladocera and copepods were by far the most common food items utilized by pygmy whitefish in Dina Lake #1 during both 2000 and 2001 (Figure 2). The frequency distribution of abundance measures, however, suggests that the fish were less selective of their prey items in 2001 compared to 2000. Many stomach samples were filled with a single abundant taxon (rank 4 or 75-100%) in 2000 (Figure 1B) but the 2001 samples often contained more than one abundant taxon (ranked 3 or 2) in individual stomachs (Figure 1C). Greater diversity of abundant taxa in many 2001 stomach samples was largely due to greater abundance of *Bosmina* and chironomidae larvae and significantly lower abundance of *Daphnia* compared to the 2000 samples (Table 2). *Daphnia*, *Bosmina*, Chironomidae larvae, and copepods (both Cyclopoida and Calanoida) were often found together in similar high abundance in the 2001 stomach samples (Appendix 2). These taxa were also found together in the same stomach samples collected during 2000 but the *Bosmina* and Chironomidae larvae were often found in low abundance (e.g. 0 – 25%; Appendix 1).

These data suggest that there was variation of ecological conditions in Dina Lake #1 between 2000 and 2001 that affected the invertebrate community differently in the lake. Consequently, in 2001 the pygmy whitefish needed to target less optimal prey (e.g. *Bosmina*, Chironomidae larvae) because their preferred prey (*Daphnia*) were less abundant. Alternatively, environmental conditions in the lake were similar between years and differences in stomach contents between 2000 and 2001 reflect different microhabitats. These hypotheses have implications for the movement and food preference for pygmy whitefish in the lake and can be distinguished by examining the limnological conditions, invertebrate abundance, and locations of fish collections between years.

There was no obvious trend in the data suggesting that two or more taxa were foraged by pygmy whitefish at the same time. In fact, when two or more relatively abundant taxa were found in the same stomach sample they were often located in distinct regions of the stomach (i.e. in the pyloric or cardiac limb). This suggests that pygmy whitefish targeted particular invertebrate prey that were swarming separately in distinct microhabitats.

The negative correlation between benthic and limnetic taxa abundance (Figure 4) suggests that pygmy whitefish used distinct foraging strategies to catch these ecotypes. Benthic taxa were clearly dominated by chironomidae larvae (Table 2) and these taxa were included in the pygmy whitefish diet during every sampling period although they made up a larger proportion of the diet during June and July of both years (Appendix 4 and 5).

Chironomidae larvae were almost always large specimens and often showed signs of metamorphosis (e.g. swelling of the thoracic region betray the initial stages of pupation; Merritt and Cummins 1996). This is not surprising since third instar chironomidae larvae can escape fish predation by burrowing deep into the substrate (Werner et al. 1983). Consequently, it is possible that chironomid larvae are most susceptible to predation by pygmy whitefish when the fourth instars migrate to the sediment-water interface to begin metamorphosis. Late fourth instar chironomidae larvae and pupae likely congregate at the surface of the benthos in specific regions on the lake bottom (they have a patchy distribution in lake benthos) offering rich foraging habitat for the pygmy whitefish.

There were no significant differences in the overall abundance measures between chironomidae larvae and pupae (Figure 5) and the life history stages made up similar proportions of the diet during most sampling periods, except for June 2001 (Appendix 4). Consequently, it is also possible that both life history stages were foraged at the same time from the same habitat. The proportion of times chironomid larvae and pupae were found in the same stomach sample was low (~15% of all chironomidae occurrences for both years; Appendix 1 and 2). However, this suggests that the pygmy whitefish targeted them using different foraging strategies. It was difficult to clearly distinguish between the two life history stages using the crushed specimens in the stomach contents, and it is likely that some very late instar chironomidae larvae were identified as pupae.

Seasonal changes in abundance of foraged items was similar in the pygmy whitefish samples collected during 2000 and 2001 with the greatest proportion of the diet consisting of copepods (mostly Cyclopoida) during June, and then Cladocera (mostly

Bosmina and *Daphnia*) during July (Appendix 4 and 5). Both Cladocera and copepods dominated the pygmy whitefish diet during August, September, and October of both years (Appendix 4 and 5). Cyclopoid copepods were clearly the most important food source for the pygmy whitefish in the spring, but an increasing abundance of Cladocera and Calanoida copepods in the diet as the season progressed suggests that these organisms are preferred prey for pygmy whitefish in Dina Lake #1.

Alternatively, the abundance in the diet directly reflects abundance of these organisms in the environment. Copepods are particularly adept at sensing the location of predators and avoiding capture with sudden rapid movement and their ability to do so increases with their size (Pennak 1996). Cladocera, however, have invested their energy into rapid reproductive rate through cloning during the productive months of the year, which enables populations to sustain larger levels of predation. Consequently, they can rapidly reach huge population sizes during the summer and offer a rich food supply that are relatively easy to catch for higher trophic levels, including fishes.

An interesting observation during processing of the stomach samples was the presence of a rich oily orange lipid on some of the stomach samples, which was difficult to quantify, as it tended to dissolve in the ethanol preservative. Nonetheless, this rich (energy rich carotenoids might be the cause of the colouration) lipid-like substance was also observed inside the bodies of Calanoida copepods, that were usually larger and more gravid with egg masses than the Cyclopoida. Such a rich food supply might offer a competitive advantage to those pygmy whitefish that can overcome the escape response of this prey. Clearly the relationship between these limnetic preys and the pygmy whitefish warrant further study.

The most important food items for pygmy whitefish in Dina Lake #1 during the summer are clearly copepods and Cladocera, which might be common among lake dwelling populations of *P. coulteri* (Carle et al. 1967; McPhail and Lindsey 1970; Scott and Crossman 1973). Cladocera, however, might be particularly important if they are more accessible to the younger and smaller adult pygmy whitefish that have not achieved the swimming speed and maneuverability required to catch the larger copepods. Cladocera abundance is closely tied to the abundance of their food source (phytoplankton), which in turn depends on warmer temperatures and ample light to survive (e.g. summer conditions; Pennak 1989).

When their food source and temperature declines, Cladocera become unavailable as food for fishes as they produce resting eggs (ephippia) that over winter in the benthos. Consequently, pygmy whitefish in Dina Lake #1 require an alternative food source during the winter and early spring, which would likely include Copepods and benthic invertebrates including Chironomidae larvae, Trichoptera larvae, Ephemeroptera naiads, amphipods (e.g. *H. azteca*) and Hydracarina (water mites).

Although the chironomids were not as abundant as copepods and cladocera in the stomach samples during spring and summer, this taxon might be a fundamental food source for pygmy whitefish during winter. Various chironomid species are able to respond to warmer periods during winter to emerge as adults (Merrit and Cummins 1996), so they could also provide food for pygmy whitefish in the water column (i.e. pupae). Similarly, many copepods survive in low densities as small adults over the winter (Pennak 1989) and are also a likely winter food source for the fish. Furthermore,

abundance of cyclopoid copepods in the stomach samples early in the year suggest that they are the first abundant food source available to pygmy whitefish in the spring.

Clearly, the pygmy whitefish depend on the abundant copepods and cladocera during the productive summer months for growth and maturation. Nonetheless, they might depend increasingly on other organisms (e.g. benthic fauna) to survive the less productive months. Presence of benthic organisms in their diet in this report clearly shows that Dina Lake #1 Pygmy whitefish can utilize a benthic foraging strategy, and this strategy might become more important at times when their preferred food sources (i.e. cladocera and copepods) are rare.

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Appendices

Appendix 1: Raw data collected during stomach contents analysis of the pygmy whitefish samples collected during the summer of 2000.

Appendix 2: Raw data collected during stomach contents analysis of the pygmy whitefish samples collected during the summer of 2001.

Appendix 3: Abundance profiles for each taxon that were used for statistical analysis.

Appendix 4: Relative abundance of invertebrate taxa found in pygmy whitefish stomach samples collected during four sample periods during 2001 (June, July, August, and October).

Appendix 5: Relative abundance of invertebrate taxa found in pygmy whitefish stomach samples collected during four sample periods during 2000 (June, July, September, and October).

Appendix 1

(2000 Raw Data)

Fish No	Stomach Fullness	Fat Content	Benthic Taxa					Limnetic Taxa							
			Ephemeroptera niad	Trichoptera Larva	Diptera larvae	Chironomidae larvae	Amphipoda *Hyalella azteca*	O. Eucopepoda S.O. Cyclopoida	O. Eucopepoda S.O. Calanoida	Diptera pupae	Chaoboridae larvae	Cladocera *Daphnia*	Cladocera *Bosmina*	Cladocera *Leptodora*	Cladocera *Alona*	Hydracarina
1	50-75	M				0%-25%		75%-100%								
2	50-75	H						75%-100%					0%-25%			
3	50-75	M						75%-100%					0%-25%			
4	50-75	M						75%-100%					0%-25%			
5	50-75	M						75%-100%					0%-25%			
6	75-100	L						75%-100%								
7	50-75	L			0%-25%			75%-100%					0%-25%			0%-25%
8	50-75	H						75%-100%					0%-25%			
9	50-75	H						0%-25%		75%-100%						
10	75-100	H						75%-100%								
11	75-100	H						75%-100%					0%-25%			
12	50-75	H						75%-100%					0%-25%			
13	75-100	H				0%-25%		75%-100%								
14	50-75	H				0%-25%		50%-75%		0%-25%			0%-25%			
15	50-75	H						75%-100%					0%-25%			
16	50-75	H						75%-100%					0%-25%			
18	50-75	H				0%-25%		75%-100%								
39	50-75	M						75%-100%								
40	50-75	M				0%-25%		75%-100%								
41	75-100	M				0%-25%		75%-100%					0%-25%			
42	50-75	H						75%-100%		0%-25%						
43	50-75	H						75%-100%								
49	50-75	H						75%-100%			0%-25%					
51	50-75	H						75%-100%								
56	50-75	H						75%-100%								
92	25-50	L						0%-25%				75%-100%				
93	25-50	M						75%-100%					0%-25%			
94	25-50	L						75%-100%								
95	50-75	L						75%-100%					0%-25%			
96	50-75	L						50%-75%					25%-50%	25%-50%		
97	50-75	L						50%-75%					25%-50%			
98	25-50	L						25%-50%					50%-75%	0%-25%		
99	50-75	M						75%-100%		0%-25%						
100	50-75	M						50%-75%		50%-75%						
101	0-25 (empty)	H														
107	50-75	L						75%-100%				0%-25%	0%-25%			
108	75-100	L						25%-50%				25%-50%	0%-25%			
109	50-75		0%-25%			50%-75%				0%-25%						
110	50-75							75%-100%					0%-25%			
111	50-75							25%-50%	25%-50%				0%-25%	0%-25%		
112	50-75							25%-50%				50%-75%				
113	50-75							25%-50%				50%-75%				
114	50-75							50%-75%				25%-50%				
115	0-25	L								75%-100%		0%-25%				
116	0-25 (empty)	L														
151	50-75	L						0%-25%				75%-100%	0%-25%	0%-25%		
152	75-100	H						0%-25%				50%-75%	0%-25%	50%-75%		
153	Sliced open in field	H						0%-25%				75%-100%				
154	75-100	H				0%-25%		75%-100%				0%-25%				
155	50-75	M-H				0%-25%		75%-100%				0%-25%	0%-25%			

Fish No	Stomach Fullness	Fat Content	Benthic Taxa					Limnetic Taxa							
			Ephemeroptera niad	Trichoptera Larva	Diptera larvae	Chironomidae larvae	Amphipoda *Hyalella azteca*	O. Eucopepoda S.O. Cyclopoida	O. Eucopepoda S.O. Calanoida	Diptera pupae	Chaoboridae larvae	Cladocera *Daphnia*	Cladocera *Bosmina*	Cladocera *Leptodora*	Cladocera *Alona*	Hydracarina
156	50-75	M-H						75%-100%		0%-25%		0%-25%	0%-25%			
157	75-100	M-H							0%-25%			75%-100%		0%-25%		
158	75-100	H						0%-25%	0%-25%			75%-100%		0%-25%		
159	75-100	H										75%-100%	0%-25%	0%-25%		
160	75-100	H							0%-25%			75%-100%		0%-25%		
161	75-100	H							0%-25%			75%-100%		0%-25%		
162	75-100	H							0%-25%			75%-100%		0%-25%		
163	50-75	H						0%-25%	0%-25%			75%-100%		0%-25%		
164	75-100	M-H						0%-25%	25%-50%			50%-75%		0%-25%		
165	75-100	M-H							0%-25%			50%-75%		0%-25%		
166	75-100	H							0%-25%			75%-100%		0%-25%		
167	75-100	M-H						0%-25%				75%-100%				
168	75-100	L-M						0%-25%	0%-25%			75%-100%				
169	75-100	M						0%-25%	0%-25%			75%-100%		0%-25%		
170	75-100	M		0%-25%					0%-25%			75%-100%		0%-25%		
171	75-100	M							0%-25%			75%-100%		0%-25%		
172	75-100	M				0%-25%			0%-25%			75%-100%		0%-25%		
173	75-100	M-H							0%-25%			75%-100%		0%-25%		
174	75-100	H				0%-25%		0%-25%	0%-25%			50%-75%		0%-25%		
175	75-100	M-H							0%-25%	0%-25%		75%-100%		0%-25%		
176	75-100	M-H						0%-25%	0%-25%			75%-100%		0%-25%		
177	50-75	M						0%-25%	0%-25%			75%-100%		0%-25%		
178	50-75	M							0%-25%			75%-100%		0%-25%		
184	25-50	H				0%-25%			0%-25%			75%-100%	0%-25%	0%-25%		
185	25-50	L				0%-25%			25%-50%			25%-50%	0%-25%	0%-25%		
186	50-75	H		0%-25%		0%-25%			25%-50%			50%-75%				
187	25-50	M-H							25%-50%			50%-75%				
188	25-50	H		0%-25%		0%-25%			25%-50%		0%-25%	25%-50%				
189	50-75	M-H							25%-50%			25%-50%				
190	25-50	M-H										75%-100%				
191	0-25	H						25%-50%				50%-75%				
192	0-25	H				25%-50%			0%-25%			25%-50%				
197	25-50	M				25%-50%				25%-50%						
198	25-50	M-H				25%-50%				25%-50%		0%-25%		25%-50%		
199	0-25	H				25%-50%			0%-25%	25%-50%	25%-50%	0%-25%				
200	25-50	H							0%-25%	50%-75%		0%-25%				
201	50-75	M-H								75%-100%						
202	25-50	H				25%-50%		0%-25%		25%-50%	0%-25%	0%-25%				
203	50-75	H								0%-25%	75%-100%	0%-25%				
204	0-25	H						0%-25%				75%-100%				
205	50-75	H				25%-50%		0%-25%			25%-50%	0%-25%				
206	75-100									75%-100%						
207	50-75	H						0%-25%				75%-100%				
208	50-75	M						25%-50%				50%-75%				
209	0-25	L							50%-75%			25%-50%	0%-25%			
210	0-25	M-H									75%-100%					
211	0-25	M-H							25%-50%			25%-50%				
212	0-25	M-H									75%-100%					
213	25-50	M-H				0%-25%			0%-25%			50%-75%	0%-25%			
214	empty	M-H														
215	25-50	M-H							0%-25%			75%-100%				

Fish No	Stomach Fullness	Fat Content	Benthic Taxa					Limnetic Taxa							
			Ephemeroptera niad	Trichoptera Larva	Diptera larvae	Chironomidae larvae	Amphipoda *Hyalella azteca*	O. Eucopepoda S.O. Cyclopoida	O. Eucopepoda S.O. Calanoida	Diptera pupae	Chaoboridae larvae	Cladocera *Daphnia*	Cladocera *Bosmina*	Cladocera *Leptodora*	Cladocera *Alona*	Hydracarina
216	empty	H														
217	25-50	M							0%-25%			75%-100%	0%-25%			
218	empty	H														
219	50-75	M-H							50%-75%			25%-50%				
220	50-75	H							50%-75%			50%-75%				
221	empty	L														
222	25-50	M-H							50%-75%			50%-75%	0%-25%			
223	empty	M-H														
224	empty	H														
225	empty	M-H														
226	empty	M														
227	25-50	H							50%-75%			50%-75%				
228	0-25	H							75%-100%			0%-25%				
229	0-25	M-H				25%-50%			25%-50%			25%-50%				
230	0-25	H							75%-100%			0%-25%				
231	empty	L														
232	50-75	H							50%-75%			50%-75%				
233	0-25	H							50%-75%			50%-75%				
263	25-50	L		0%-25%					0%-25%			50%-75%	0%-25%			50%-75%
264	50-75	L-M				0%-25%		0%-25%	25%-50%			50%-75%	0%-25%			
265	0-25	M							25%-50%			50%-75%	0%-25%			
266	50-75	M-H							50%-75%			50%-75%	0%-25%			
267	25-50	H							0%-25%			75%-100%				
268	50-75	L-M					25%-50%		0%-25%			50%-75%	0%-25%			
270	empty	L														
271	25-50	L-M							0%-25%			75%-100%	0%-25%			
273	50-75	M							50%-75%			25%-50%	0%-25%			
274	25-50	L-M					75%-100%					0%-25%				
276	0-25	L-M							50%-75%			50%-75%				
279	50-75	M-H						0%-25%	0%-25%			50%-75%	25%-50%			0%-25%
295	0-25	M-H									75%-100%					
296	0-25	M							25%-50%			25%-50%	25%-50%			
297	0-25	L-M						50%-75%				50%-75%				
299	75-100	L-M						0%-25%	25%-50%			50%-75%	0%-25%			
300	75-100	M							0%-25%			75%-100%	0%-25%			
301	75-100	M							50%-75%			50%-75%	0%-25%			
302	50-75	M-H				0%-25%			0%-25%			75%-100%	0%-25%			
303	25-50	L-M							0%-25%			50%-75%	0%-25%			
304	25-50	L-M							0%-25%			75%-100%				
305	50-75	M							25%-50%			25%-50%	0%-25%			
306	50-75	L-M							25%-50%			50%-75%	0%-25%		0%-25%	
307	75-100	L-M							0%-25%			50%-75%	0%-25%			
308	0-25	L-M						0%-25%				75%-100%				
309	0-25	L										75%-100%				
310	25-50	L-M										75%-100%			0%-25%	
311	0-25	L-M							0%-25%			75%-100%				
319	75-100	M							25%-50%			50%-75%	0%-25%			
320	25-50	L-M						0%-25%	0%-25%			50%-75%	0%-25%		0%-25%	

Appendix 2

2001 Raw Data

Fish #	Stomach Fullness	Fat Content	Benthic Taxa					Limnetic Taxa								
							Amphipoda	O. Eucopepoda				Cladocera				
			Ephemeroptera naiad	Trichoptera Larva	Diptera larvae	Chironomidae larvae	*Hyalella azteca*	S.O. Cyclopoida	S.O. Calanoida	Chironomidae pupae	Chaoboridae larvae	*Daphnia*	*Bosmina*	*Leptodora*	*Alona*	Hydracarina
May																
1	25-50	M				0-25		50-75		25-50						
2	50-75	M				0-25		75-100		25-50						
3	50-75	M				0-25		0-25		50-75						
June																
5	25-50	L						50-75		0-25		0-25	0-25			
6	75-100	H						50-75				0-25	0-25			
7	75-100*	H						50-75				0-25	25-50			
8	75-100	H						50-75				0-25	50-75			
9	75-100	H						75-100					0-25			
10	75-100	H						50-75				0-25	25-50			
11	50-75	M				0-25		50-75					50-75			
17	25-50	L				0-25		25-50		0-25			25-50			
18	75-100	M				0-25		75-100					0-25			
19	75-100	M				0-25		50-75			0-25		0-25			
20	50-75*	H				0-25		50-75		0-25	0-25					
24	75-100	H						75-100		0-25			0-25			
25	25-50	H				0-25		25-50					25-50			
27	25-50	H						50-75		0-25		0-25	25-50			
29	25-50	H				0-25		50-75					0-25			
31	0-25	H				0-25		50-75					0-25			
32	50-75	H						50-75				0-25	0-25			
33	75-100	H				0-25		75-100				0-25				
34	75-100	H				0-25		25-50		25-50			0-25			
35	50-75	H						75-100								
38	25-50	M				25-50		25-50		25-50	25-50					
39	50-75*	M				50-75		0-25			25-50					
40	75-100	H				75-100					0-25					
42	50-75	H				50-75Cardiac		25-50Pyloric			0-25Cardiac					
43	75-100	H				25-50 Pyloric		50-75Cardiac		0-25Pyloric						
44	50-75	H				50-75Pyloric		25-50Cardiac								

Fish #	Stomach Fullness	Fat Content	Benthic Taxa					Limnetic Taxa								
							Amphipoda	O. Eucopepoda				Cladocera				
			Ephemeroptera naiad	Trichoptera Larva	Diptera larvae	Chironomidae larvae	*Hyalella azteca*	S.O. Cyclopoida	S.O. Calanoida	Chironomidae pupae	Chaoboridae larvae	*Daphnia*	*Bosmina*	*Leptodora*	*Alona*	Hydracarina
45	50-75*	M				50-75		25-50			0-25					
46	75-11*	H				25-50		0-25			25-50					
47	75-100	H				50-75		25-50			25-50		0-25			
48	50-75	H				25-50		50-75		0-25						
49	50-75	M				25-50		0-25			25-50					
50	75-100	M				50-75		25-50			25-50					
July																
52	75-100	M											75-100			
53	75-100	L							0-25			25-50	25-50	0-25		
54	75-100	L							0-25			25-50	50-75			
55	50-75	L							0-25			0-25	50-75			
57	75-100	M							0-25			0-25	50-75			
58	75-100	M							0-25			0-25	75-100			
59	75-100	H	0-25					0-25	0-25			25-50	25-50			
60	50-75	L						0-25				25-50	50-75			
61	50-75	L							0-25	50-75		0-25	0-25			
62	75-100*	H							0-25			50-75	25-50			
63	75-100	H							0-25			25-50	50-75			
64	75-100	H						0-25	0-25			50-75	25-50			
66	50-75	L				50-75							25-50			
67	50-75	L								75-100						
68	50-75	L								75-100						
69	25-50	L								50-75			25-50			
71	75-100*	L										25-50	50-75			
72	50-75	H							0-25			25-50	50-75			
74	75-100	H										25-50	50-75			
75	25-50	H				25-50						0-25	50-75			
76	75-100	H							0-25	0-25		25-50	25-50			
77	75-100	H				25-50 (Cardiac)							50-75 (Pyloric)			
78	0-25	M														75-100

Fish #	Stomach Fullness	Fat Content	Benthic Taxa					Limnetic Taxa								
							Amphipoda	O. Eucopepoda				Cladocera				
			Ephemeroptera naiad	Trichoptera Larva	Diptera larvae	Chironomidae larvae	*Hyalella azteca*	S.O. Cyclopoida	S.O. Calanoida	Chironomidae pupae	Chaoboridae larvae	*Daphnia*	*Bosmina*	*Leptodora*	*Alona*	Hydracarina
79	25-50	M				75-100							0-25			
82	25-50*	H										0-25	75-100			
83	0-25	L								0-25		25-50	25-50			
85	50-75	M						25-50	25-50			25-50	25-50			
87	75-100	H						25-50	25-50			25-50	25-50			
89	75-100	H						0-25	0-25			50-75				
90	75-100	H						25-50	25-50			25-50	0-25			
91	50-75	L						50-75	0-25			0-25			0-25	
Aug.																
151	empty	L														
184	50-75	H							0-25	50-75				25-50		
186	0-25	L										75-100				
189	25-50	H							0-25			50-75		25-50		
190	empty	H														
191	50-75	M							25-50	25-50		25-50	0-25			0-25
192	50-75	M										50-75		25-50		
193	0-25	H							25-50			25-50				
194	0-25	M							25-50			25-50				
195	75-100	H							0-25			75-100		0-25		
196	75-100	H							0-25			75-100		0-25		
197	empty	H														
198	50-75	H							0-25			75-100		0-25		
199	0-25	H								75-100						
200	empty	H														
201	empty	H														
202	50-75	H							0-25			75-100				
203	empty	M														
204	25-50	H						0-25	75-100			0-25	0-25			
205	50-75	H							0-25			50-75		25-50		
206	empty	M														
207	0-25*	M							25-50	50-75						

Fish #	Stomach Fullness	Fat Content	Benthic Taxa					Limnetic Taxa								
							Amphipoda	O. Eucopepoda				Cladocera				
			Ephemeroptera naiad	Trichoptera Larva	Diptera larvae	Chironomidae larvae	*Hyalella azteca*	S.O. Cyclopoida	S.O. Calanoida	Chironomidae pupae	Chaoboridae larvae	*Daphnia*	*Bosmina*	*Leptodora*	*Alona*	Hydracarina
208	0-25	H							75-100							
209	empty	L														
210	25-50	L						0-25	75-100							
211	0-25	L							75-100				0-25			
212	25-50	L						50-75	25-50							
213	0-25	L				25-50		25-50	0-25				0-25			
214	50-75	L				50-75		0-25								
215	25-50*	L						75-100							0-25	
216	50-75*	L				25-50		0-25	25-50							
217	25-50	L						75-100							0-25	
218	25-50	L				75-100										
252	empty	H														
253	empty	H							75-100							
254	50-75	L						50-75				25-50				
255	0-25	H														
256	empty	H														
Oct.												75-100				
257	25-50	L														
258	empty	L														
259	empty	M							0-25			0-25				
260	25-50	H				75-100			0-25			75-100				
261	25-50	M							25-50			25-50	25-50			
262	50-75*	L							0-25			75-100				
263	?*	L										25-50	25-50			
264	25-50	M				0-25						50-75				
265	25-50*	L						0-25	0-25				25-50			
266	0-25	L						25-50	25-50				75-100			
267	0-25	L														
268	0-25	L						75-100								
269	0-25	L							0-25			25-50	25-50			
270	25-50	L						0-25		75-100		0-25	0-25			

Fish #	Stomach Fullness	Fat Content	Benthic Taxa					Limnetic Taxa								
							Amphipoda	O. Eucopepoda				Cladocera				
			Ephemeroptera naiad	Trichoptera Larva	Diptera larvae	Chironomidae larvae	*Hyalella azteca*	S.O. Cyclopoida	S.O. Calanoida	Chironomidae pupae	Chaoboridae larvae	*Daphnia*	*Bosmina*	*Leptodora*	*Alona*	Hydracarina
271	25-50	L						25-50	25-50				25-50			
272	25-50	L						25-50				50-75	0-25			
273	0-25	L											75-100			
274	50-75	L											75-100		0-25	
275	25-50	L						0-25		75-100						
276	25-50	L											75-100			
277	empty	L														
278	0-25	L						25-50					25-50			
279	empty	L														
280	empty	L														
281	empty	H														
282	empty	M														
283	empty	L														
289	empty	H														
290	0-25	L							0-25			75-100				
Nov.																
360	75-100*	L				0-25		0-25	0-25			25-50	50-75		0-25	
361	75-100*	L						0-25	0-25			25-50	50-75			

Appendix 3

Abundance Profiles

Chironomidae larvae	Chironomidae pupae	S.O. Cyclopoida	S.O. Calanoida	Chaoboridae larvae	Daphnia	Bosmina	Leptodora	Alona	Ephemeroptera niad	Trichoptera Larva
				2000 DATA						
0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%
0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%		0%-25%
0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%	0%-25%		0%-25%
0%-25%	0%-25%	0%-25%	0%-25%	25%-50%	0%-25%	0%-25%	0%-25%			0%-25%
0%-25%	0%-25%	0%-25%	0%-25%	25%-50%	0%-25%	0%-25%	0%-25%			
0%-25%	0%-25%	0%-25%	0%-25%	75%-100%	0%-25%	0%-25%	0%-25%			
0%-25%	0%-25%	0%-25%	0%-25%	75%-100%	0%-25%	0%-25%	0%-25%			
0%-25%	25%-50%	0%-25%	0%-25%	75%-100%	0%-25%	0%-25%	0%-25%			
0%-25%	25%-50%	0%-25%	0%-25%	75%-100%	0%-25%	0%-25%	0%-25%			
0%-25%	25%-50%	0%-25%	0%-25%		0%-25%	0%-25%	0%-25%			
0%-25%	25%-50%	0%-25%	0%-25%		0%-25%	0%-25%	0%-25%			
0%-25%	50%-75%	0%-25%	0%-25%		0%-25%	0%-25%	0%-25%			
0%-25%	50%-75%	0%-25%	0%-25%		0%-25%	0%-25%	0%-25%			
0%-25%	75%-100%	0%-25%	0%-25%		0%-25%	0%-25%	0%-25%			
0%-25%	75%-100%	0%-25%	0%-25%		25%-50%	0%-25%	0%-25%			
0%-25%	75%-100%	0%-25%	0%-25%		25%-50%	0%-25%	0%-25%			
0%-25%	75%-100%	0%-25%	0%-25%		25%-50%	0%-25%	0%-25%			
25%-50%		0%-25%	0%-25%		25%-50%	0%-25%	0%-25%			
25%-50%		0%-25%	0%-25%		25%-50%	0%-25%	0%-25%			
25%-50%		0%-25%	0%-25%		25%-50%	0%-25%	0%-25%			
25%-50%		0%-25%	0%-25%		25%-50%	0%-25%	0%-25%			
25%-50%		0%-25%	0%-25%		25%-50%	0%-25%	0%-25%			
25%-50%		0%-25%	0%-25%		25%-50%	0%-25%	0%-25%			
25%-50%		25%-50%	0%-25%		25%-50%	0%-25%	0%-25%			
50%-75%		25%-50%	0%-25%		25%-50%	0%-25%	0%-25%			
		25%-50%	0%-25%		25%-50%	0%-25%	25%-50%			
		25%-50%	0%-25%		25%-50%	0%-25%	25%-50%			
		25%-50%	0%-25%		50%-75%	0%-25%	50%-75%			
		25%-50%	0%-25%		50%-75%	0%-25%				
		25%-50%	0%-25%		50%-75%	0%-25%				
		50%-75%	0%-25%		50%-75%	0%-25%				
		50%-75%	0%-25%		50%-75%	0%-25%				
		50%-75%	0%-25%		50%-75%	0%-25%				
		50%-75%	0%-25%		50%-75%	0%-25%				
		50%-75%	0%-25%		50%-75%	0%-25%				

Chironomidae larvae	Chironomidae pupae	S.O. Cyclopoida	S.O. Calanoida	Chaoboridae larvae	Daphnia	Bosmina	Leptodora	Alona	Ephemeroptera niad	Trichoptera Larva
		50%-75%	0%-25%		50%-75%	0%-25%				
		75%-100%	0%-25%		50%-75%	0%-25%				
		75%-100%	0%-25%		50%-75%	0%-25%				
		75%-100%	25%-50%		50%-75%	0%-25%				
		75%-100%	25%-50%		50%-75%	0%-25%				
		75%-100%	25%-50%		50%-75%	0%-25%				
		75%-100%	25%-50%		50%-75%	0%-25%				
		75%-100%	25%-50%		50%-75%	0%-25%				
		75%-100%	25%-50%		50%-75%	0%-25%				
		75%-100%	25%-50%		50%-75%	25%-50%				
		75%-100%	25%-50%		50%-75%	25%-50%				
		75%-100%	25%-50%		50%-75%	25%-50%				
		75%-100%	25%-50%		50%-75%	25%-50%				
		75%-100%	25%-50%		50%-75%	50%-75%				
		75%-100%	25%-50%		50%-75%	50%-75%				
		75%-100%	25%-50%		50%-75%	50%-75%				
		75%-100%	50%-75

Chironomidae larvae	Chironomidae pupae	S.O. Cyclopoida	S.O. Calanoida	Chaoboridae larvae	Daphnia	Bosmina	Leptodora	Alona	Ephemeroptera niad	Trichoptera Larva
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					
					75%-100%					

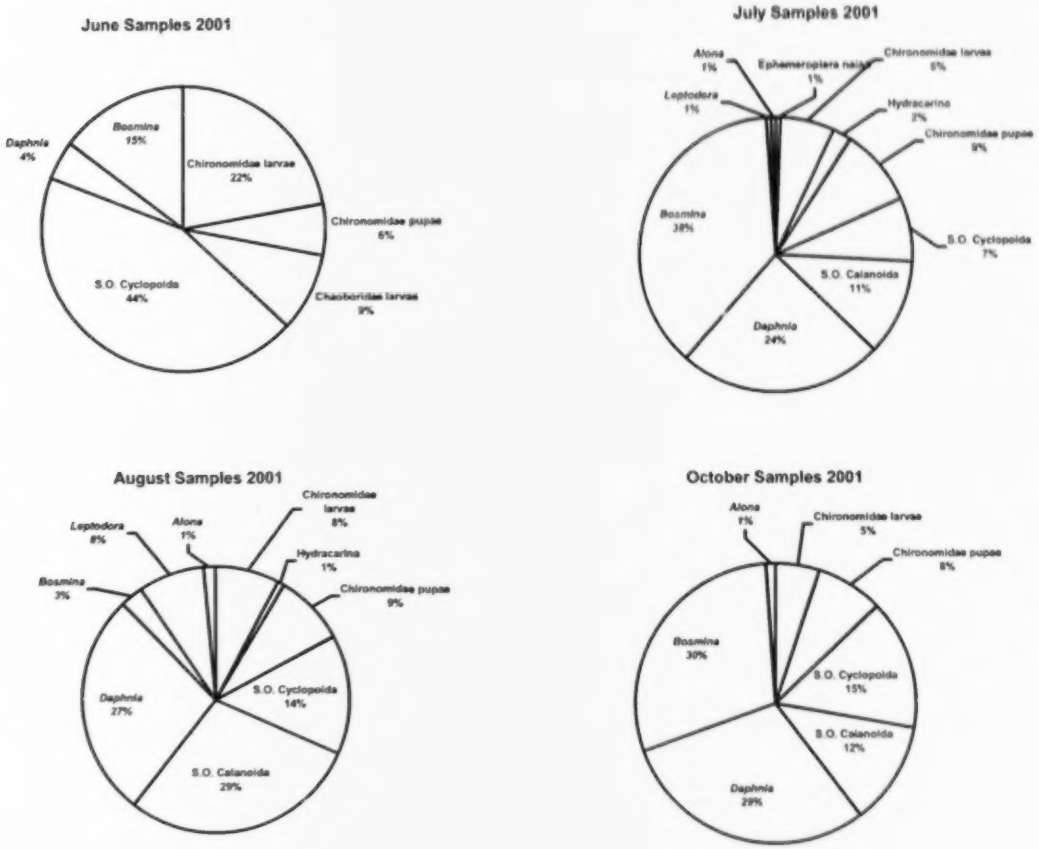
2001 DATA

Chironomidae larvae	Chironomidae pupae	S.O. Cyclopoida	S.O. Calanoida	Chaoboridae larvae	Daphnia	Bosmina	Leptodora	Alona	Ephemeroptera niad	Trichoptera Larva
0-25	0-25	0-25	0-25	0-25	0-25	0-25	0-25	0-25	0-25	
0-25	0-25	0-25	0-25	0-25	0-25	0-25	0-25	0-25		
0-25	0-25	0-25	0-25	0-25	0-25	0-25	0-25	0-25		
0-25	0-25	0-25	0-25	0-25	0-25	0-25	0-25	0-25		
0-25	0-25	0-25	0-25	0-25	0-25	0-25	25-50	0-25		
0-25	0-25	0-25	0-25	25-50	0-25	0-25	25-50			
0-25	0-25	0-25	0-25	25-50	0-25	0-25	25-50			
0-25	0-25	0-25	0-25	25-50	0-25	0-25	25-50			
0-25	25-50	0-25	0-25	25-50	0-25	0-25				
0-25	25-50	0-25	0-25		0-25	0-25				
0-25	25-50	0-25	0-25		0-25	0-25				
0-25	25-50	0-25	0-25		0-25	0-25				
0-25	25-50	0-25	0-25		0-25	0-25				
25-50	50-75	0-25	0-25		0-25	0-25				
25-50	50-75	0-25	0-25		0-25	0-25				
25-50	50-75	25-50	0-25		0-25	0-25				
25-50	50-75	25-50	0-25		0-25	0-25				
25-50	50-75	25-50	0-25		25-50	25-50				
25-50	75-100	25-50	0-25		25-50	25-50				
25-50	75-100	25-50	0-25		25-50	25-50				
25-50	75-100	25-50	0-25		25-50	25-50				
25-50	75-100	25-50	0-25		25-50	25-50				
50-75	75-100	25-50	0-25		25-50	25-50				
50-75		25-50	0-25		25-50	25-50				
50-75		25-50	0-25		25-50	25-50				
50-75		25-50	0-25		25-50	25-50				
50-75		25-50	0-25		25-50	25-50				
50-75		25-50	25-50		25-50	25-50				
50-75		25-50	25-50		25-50	25-50				
75-100		25-50	25-50		25-50	25-50				
75-100		25-50	25-50		25-50	25-50				
75-100		50-75	25-50		25-50	25-50				
75-100		50-75	25-50		25-50	25-50				
		50-75	25-50		25-50	25-50				
		50-75	25-50		25-50	25-50				
		50-75	25-50		25-50	25-50				
		50-75	25-50		25-50	25-50				
		50-75	25-50		25-50	25-50				
		50-75	25-50		50-75	25-50				

Chironomidae larvae	Chironomidae pupae	S.O. Cyclopoida	S.O. Calanoida	Chaoboridae larvae	Daphnia	Bosmina	Leptodora	Alona	Ephemeroptera niad	Trichoptera Larva
		50-75	25-50		50-75	25-50				
		50-75	75-100		50-75	50-75				
		50-75	75-100		50-75	50-75				
		50-75	75-100		50-75	50-75				
		50-75	75-100		50-75	50-75				
		50-75	75-100		50-75	50-75				
		50-75			50-75	50-75				
		50-75			75-100	50-75				
		50-75			75-100	50-75				
		50-75			75-100	50-75				
		50-75			75-100	50-75				
		75-100			75-100	50-75				
		75-100			75-100	50-75				
		75-100			75-100	50-75				
		75-100			75-100	50-75				
		75-100			75-100	75-100				
		75-100				75-100				
		75-100				75-100				
		75-100				75-100				
		75-100				75-100				
						75-100				
						75-100				

Appendix 4

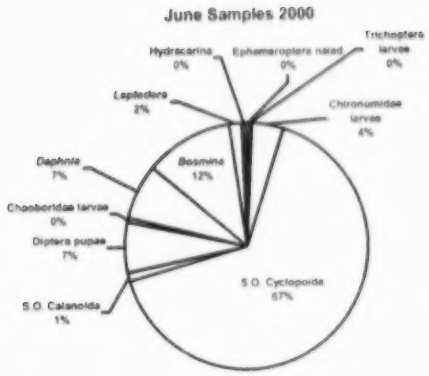
Relative Abundance, 2001

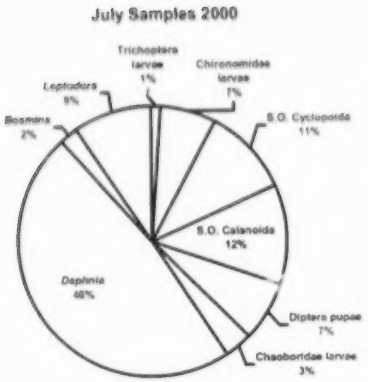


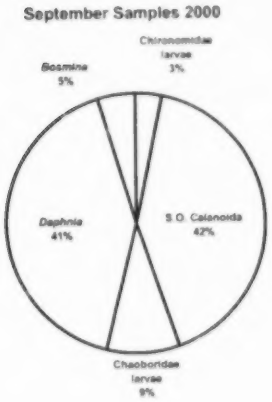
Relative abundance of invertebrate taxa found in pygmy whitefish stomach samples collected during four sample periods during 2001 (June, July, August, and October).

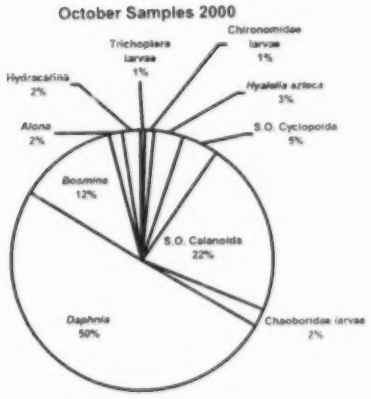
Appendix 5

Relative Abundance, 2000









Relative abundance of invertebrate taxa found in Pygmy whitefish stomach samples collected during four sample periods during 2000 (June, July, September, and October). Note that the "Diptera pupae" include Chironomidae pupae and are likely made up entirely of this taxon as in the 2001 stomach samples.